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Progress Report on Design, Risk, Hazard, and Performance-Based Codes

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Abstract

Recent activity in the US regarding fire risk and hazard analysis has included validation and data development but has primarily emphasized the steps required to refine such calculation methods for use in performance-based design and codes, including the development of appropriate organizational arrangements and procedures.

Institutionalization of Fire Hazard and Risk Analysis

Since the last UJNR meeting, there has been an unprecedented level of activity in the area of fire risk and hazard analysis methods, particularly as applied to performance-based design, codes and standards. Much of this activity has focused on organizational arrangements and innovative procedures to make engineered fire safety routine, as opposed to new approaches to the calculation methods themselves. Also, this work is increasingly multi-national, even global, which makes it increasingly difficult to isolate progress in the US. Accordingly, this progress report includes reference to work by some non-US researchers where that work has proved particularly influential in the US.

Several important papers were delivered or published on the subject of general approaches to fire risk or hazard analysis suitable for use in a performance-based code [5, 17, 40]. Most were general, but one addressed trade-offs of several major components of fire protection (detection, suppression, construction) without addressing all components (e.g., omitting prevention and evacuation) [6]. The US-based American Society for Testing and Materials (ASTM) published a standard which contains the format to be used in ASTM to write standards (typically standards for products that could burn) using a fire hazard assessment format [41]. A second standard, based on the first, will provide guidance in writing fire risk assessment standards and is now being voted on.

Other papers focused specifically on the steps required to reshape existing code-writing procedures to accommodate performance-based approaches [8, 20, 24, 37, 38]. Several of these papers were intended to acquaint important US fire safety organizations, such as the National Fire Protection Association [36] and the Society of Fire Protection Engineers [28], with the status of performance-based code design around the world.

Still other work has served to assemble known methods of fire risk or hazard assessment in one place so as to facilitate application of the methods and education of prospective users. Examples include the publication of basic documentation on CFAST [32] and FPEtool [9], two multi-part methods capable of modeling many aspects of fire and serving as the fire effects core of fire hazard or risk assessment models. Others include compilations of available methods applicable to fire risk analysis for products [18], buildings [45], industrial settings [2], and rail transportation properties [33].

Within the US, much attention has been given to emerging national performance-based code approaches in Australia [3], Canada [7, 16, 19, 23, 35, 46], and New Zealand [4]. Each has been used as a basis for design choices in the US, but with the major difference that fire codes in the US are not operated through an agency of the national government. Changes must be implemented through several private groups that develop model codes.

Components of Fire Hazard and Risk Analysis for Performance-Based Designs or Codes

There is now general agreement on the major elements required to support the institutionalized use of fire risk or hazard analysis methods within a performance-based code: (a) identification and documentation of suitable fire models whose valid uses and limitations are known and whose capabilities have been validated; (b) identification and development of data appropriate to those models and the intended applications of them; (c) fire safety goals, objectives, criteria, acceptable levels, and safety factors that translate the national consensus of values into a form suitable to guide analysis to evaluate designs; (d) identification of fire scenarios that can be analyzed using the models and the data and thereby used to define the conditions under which the fire safety goals must be met; and (e) provisions for education, certification, or accountability of fire safety engineers or others who may be asked to show that goals will be met.

Since the last UJNR meeting, there have been a number of papers published on validation of models relevant to the construction of fire hazard and risk assessment methods [14, 19, 25, 34].

Other papers have addressed data. Some have provided specific data addressed to particular issues, including factors in the propensity of different cigarettes to cause fires [21]; human behavior when confronted with a major incident in a high-rise building [12]; behavior changes induced by changes in cigarette lighter design, which may affect the impact of the design on fire risk [43]; factors leading to high vs. low fire risk in residential settings [39]; fire conditions associated with most fire deaths due to toxic effects [15]; and new probabilistic measures of the effects of sprinklers [29]. More general reviews of data needs or data usage procedures also appeared [30], some specific to special environments, such as spacecraft [1]. One article provided a compilation of the implied cost per year of life saved for each of 500 US government regulations, including many related to fire [42]. Yet another article addressed the issue of safety factors in general terms [26].

A number of articles appeared providing material on fire risk or hazard analysis in industrial settings [22], including spacecraft [1], chemical process industries [2], offshore oil platforms [13, 31, 44], and nuclear power plants [27].

Finally, miscellaneous papers addressed fire-related issues of risk perception [11] and the application to fire safety engineering of some less-recognized methods developed in the field of operations research, such as the analytical hierarchy procedure for addressing multiple objectives [10].

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Discussion

Henry Mitler: Could you give us some numbers about the value of lives saved?

John Hall: The study I referred to examined 500 different U.S. Government-related programs and analyzed their cost and of the number of lives that they saved. Their calculated ratios found, as one might expect, a tremendous variation: multiple orders of magnitude in the value of life that those agencies had achieved.

Professor Pagni: I too was very interested in the study of life evaluation. Can you tell us which of your references gives that information in detail and can you tell us anything more about it?

John Hall: Look for reference 42 in the written paper.